THE

Indian Tea Association

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL

PART I

1931

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THE QUARTERLY JOURNAL FOR 1931

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EFFECT ON TEA CROP OF DIFFERENT APPLICATIONS OF NITROGEN AS MANURE, IN SINGLE AND IN DIVIDED DOSES.

By

H. R. Cooper.

These experiments were performed on 3 acres of tea planted in 1922, divided into 70 plots, from which separate records had been kept for four years previous to the experiment. The 70 plots were divided into 7 blocks of irregular shape so that the yields of the ten plots within each block had been as nearly alike as possible. The plots within any one block are therefore fairly comparable. Ten series of 7 plots each were then selected so that one plot of each series fell into each block and so that the total yields of the ten series had been practically the same in 1928 and in 1929, and they were little different in 1927 and 1926. A study of the plan given with the appendix will make this clear.

We may look upon the tea as divided into ten composite plots all of which had yielded almost exactly alike for two years and were therefore likely to continue to yield similarly in the future if treatment continued to be similar. Any differences which have arisen after difference in treatment may be ascribed to the effect of the treatments.

The exact details of the experiment are given in the appendix.

The effects of the following treatments were measured :—

Series No. 1. No manure—check plots.

Effect of increasing quantities of nitrogen in one dose.

Series 2. 40 lbs. nitrogen in one dose on March 15th.

,, 3. 80 ,, ,, ,, ,, ,, ,, ,, ,,

,, 4. 120 ,, ,, ,, ,, ,, ,, ,, ,,

Effect of applying the above quantities in two half doses.

Series 5. 20 lbs. nitrogen on March 15th and 20 lbs. nitrogen on June 15th.

„ 6. 40 „ „ „ „ „ „ 40 „ „ „ „ „

„ 7. 60 „ „ „ „ „ „ 60 „ „ „ „ „

Effect of time of application of second dose.

Series 8. 40 lbs. nitrogen on March 15th and 40 lbs. on May 15th.

„ 6. „ „ „ „ „ „ „ „ „ „ June 15th.

„ 9. „ „ „ „ „ „ „ „ „ „ July 15th.

Effect of three applications.

Series 10. { 40 lbs. nitrogen on March 15th.
40 „ „ „ May 15th.
40 „ „ „ July 15th.

In each case the nitrogen was applied as sulphate of ammonia; each 2 lbs. nitrogen being accompanied by 1 lb. phosphoric acid as superphosphate and 1 lb. potash as sulphate of potash.

Effect of increasing doses of nitrogen in single and in divided doses.

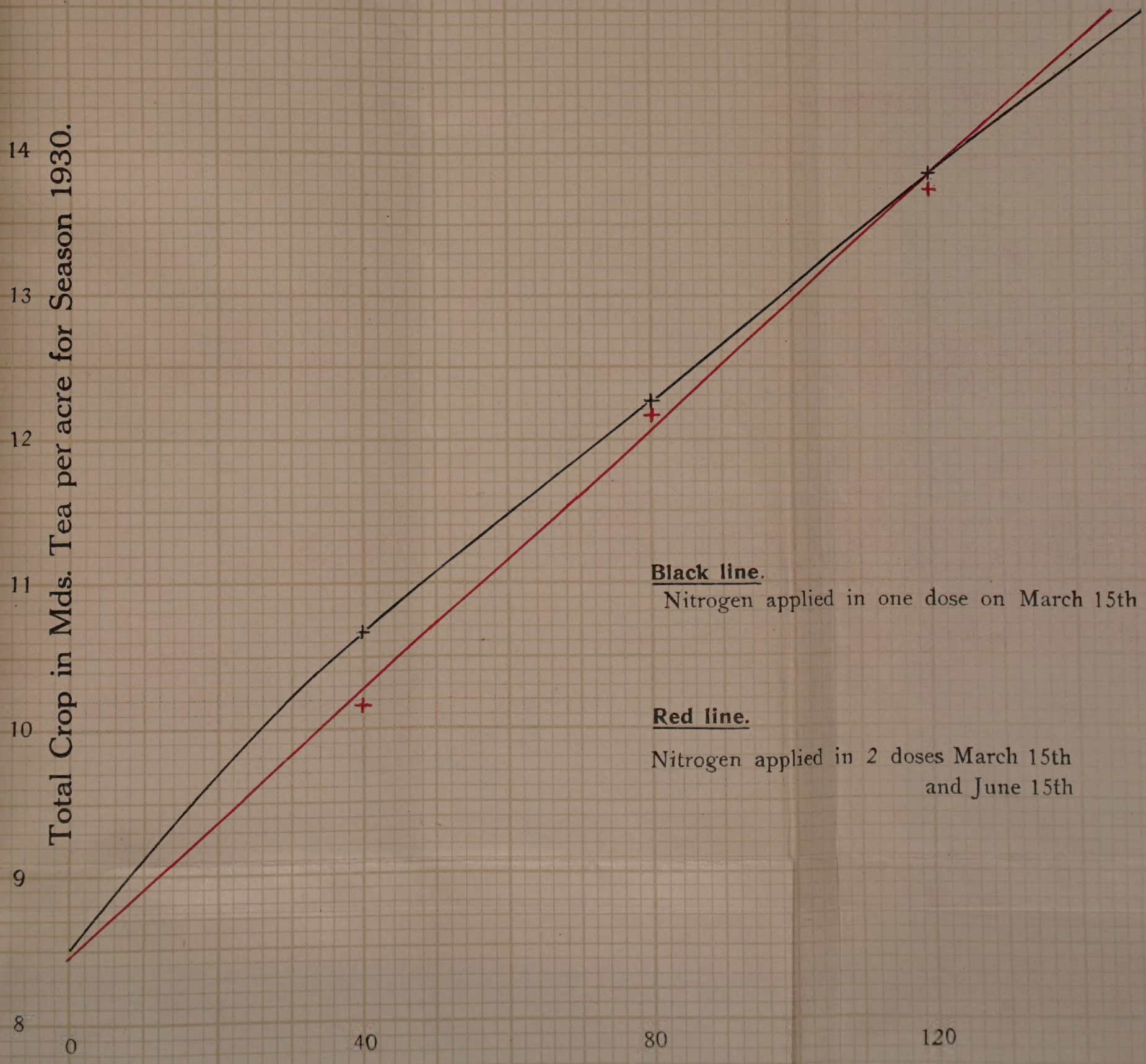
In the following Table are given the results calculated to mds. tea per acre obtained by the application of three different quantities of nitrogen, in single and in divided doses.

Series.	Total nitrogen lbs. per acre.	Applied in one dose on March 15th.		Applied in two doses, March 15th and June 15th.		Applied in three doses March 15th. May 15th. and July 15th.	
		Mds. tea per acre.	gain.	mds. tea Per acre.	gain.	mds. tea per acre.	gain.
1 ...	*nil.*	8·48	...	8·48	...	8·48	...
2 & 5 ...	40	10·66	2·18	10·14	1·66	...	...
3 & 6 ...	80	12·25	3·77	12·13	3·65	...	...
4, 7 & 10 ...	120	13·82	5·34	13·75	5·27	13·13	4·65

Considering first the effect of the two doses, it will be observed that the crop increase obtained is practically proportional to the quantity of nitrogen applied. When the reeults are plotted (see Graph No. 1 facing this page) it will be seen that the only curve which can be drawn is a straight line, and such a straight line can be drawn that none of the four results

GRAPH No. 1

Effect of Increasing applications of Nitrogen as manure in First Year of manuring.

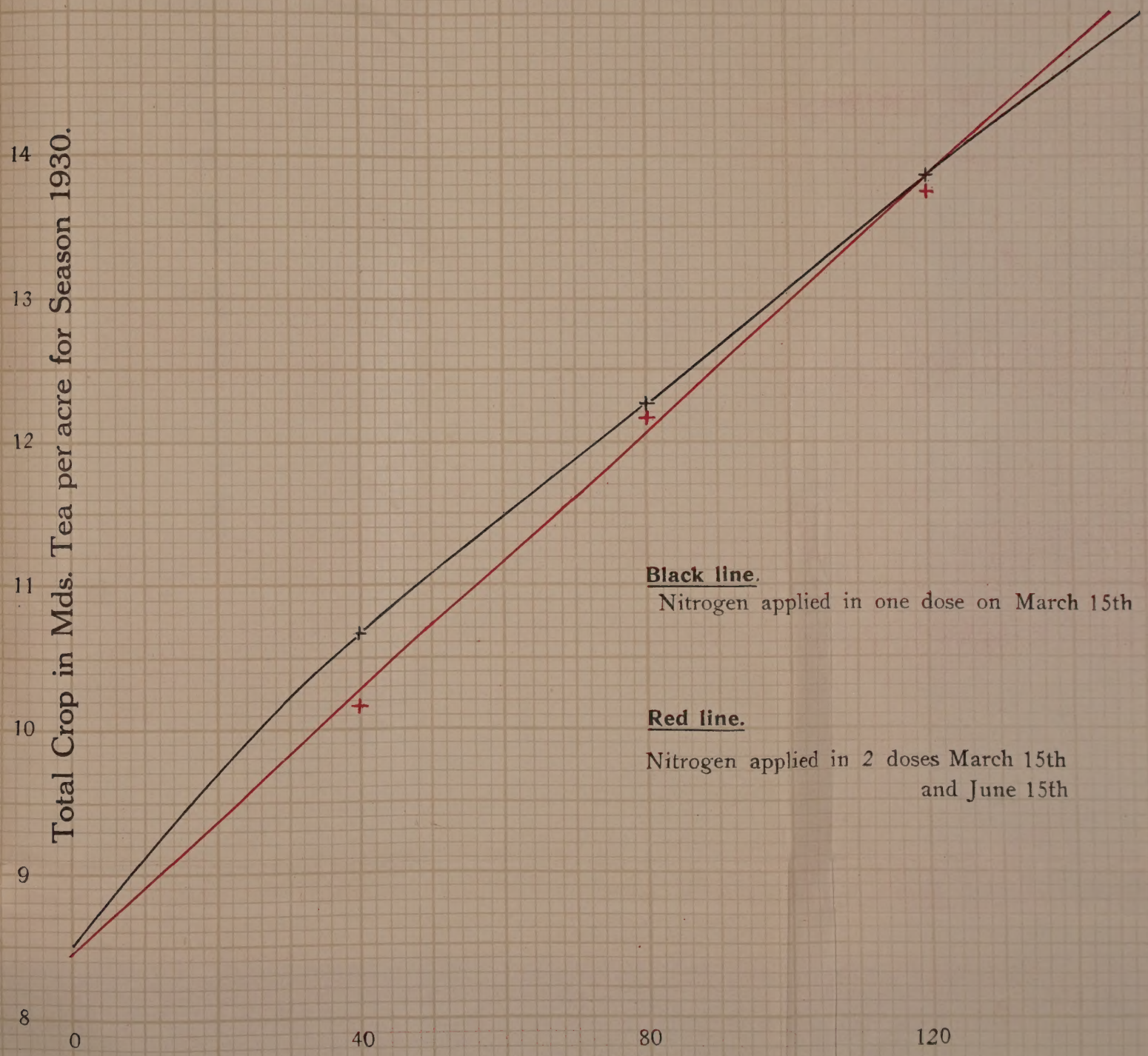


Black line.
Nitrogen applied in one dose on March 15th

Red line.
Nitrogen applied in 2 doses March 15th and June 15th

GRAPH No. 1

Effect of Increasing applications of Nitrogen as manure in First Year of manuring.



actually obtained, differ from those read from the curve by more than one tenth of a maund, which difference is certainly within experimental error.

When the same total quantities of nitrogen per acre are applied in one dose in March, almost the same crops are obtained as from the divided doses, except in the case of the total application of 40 lbs. nitrogen per acre. In this case there is a crop difference of 0.52 mds. tea per acre in favour of the single application, and this difference is considered to be significant and greater than experimental error could account for (see appendix).

The results of this experiment therefore show that it has paid to apply a total of 40 lbs. nitrogen in one single dose rather than in divided doses: but that in the cases of doses of 80 and 120 lbs. nitrogen there is little difference in crop obtained, whether the total be applied in one dose or in two. This conclusion of course applies only to the first year of application. Earlier experiments (described in the Annual Report for 1930) though less accurate, indicate that, after a series of years, it makes no difference to total crop whether manures in any quantity be applied in single or in divided doses.

The times at which the crops are made, are however, also of importance.

The monthly crops from single and divided doses are quoted below. Graph No. 2, facing this page shows more clearly the effect of application of two doses of 40 lbs. compared to one dose of 80 lbs., and also to one dose of 40 lbs.

Total of 80 lbs. nitrogen per acre.

lbs. nitrogen per acre.	Increase in mds. tea per acre over unmanured check plots						
	to end June.	July.	Aug.	Sept.	Oct.	Nov.	Total.
Single dose of 80 lbs. on March 15th ...	·58	·42	·78	1·05	·71	·23	3·77
2 doses of 40 lbs. each on March 15th and June 15th ...	30	·38	·77	1·10	·80	·30	3·65

From the single dose there is a much greater increase to the end of June, but lesser increases from September onwards, the total for the season being about the same in both cases.

Total of 120 lbs. nitrogen per acre.

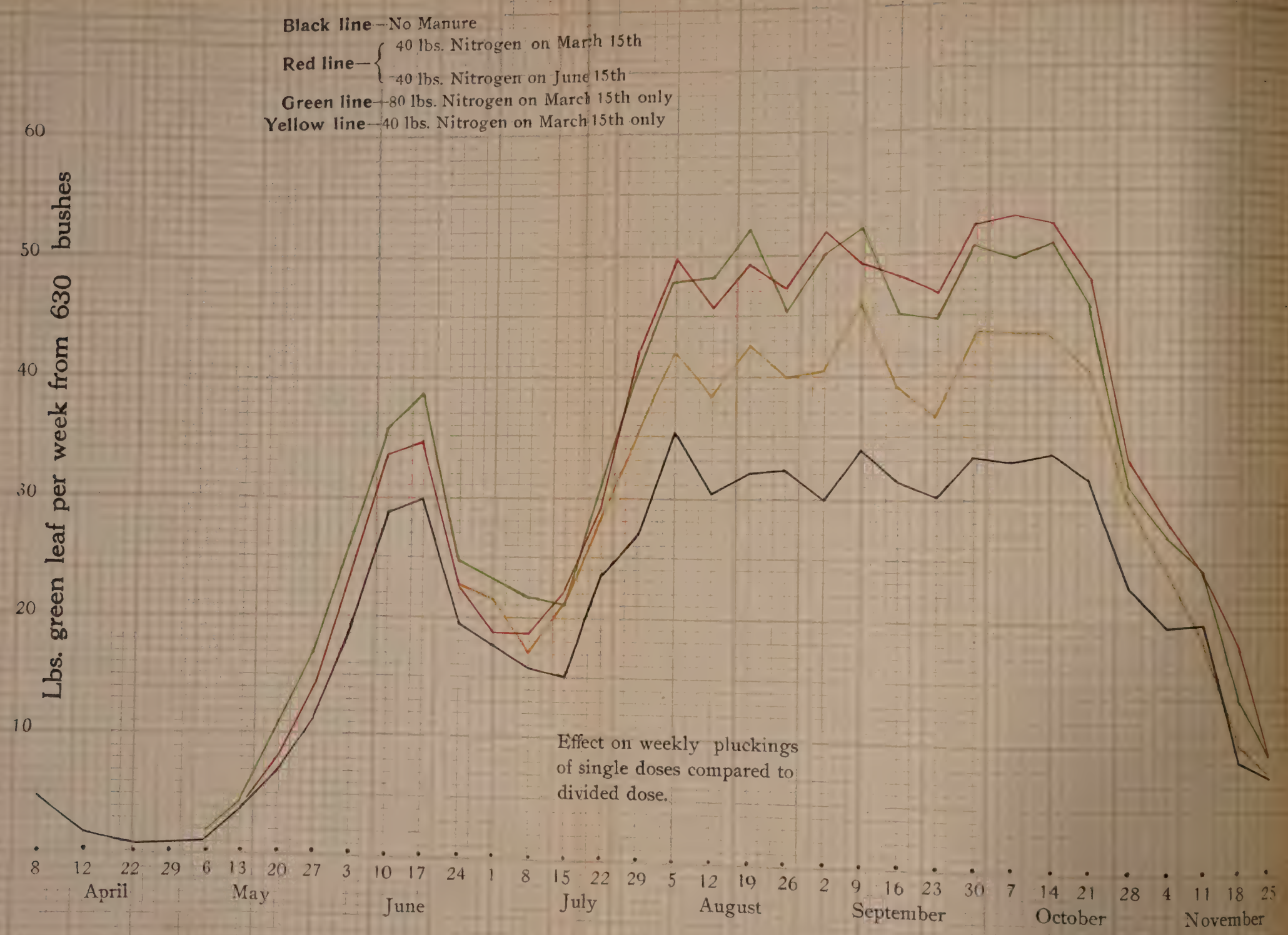
lbs. nitrogen per acre.	Increase in mds. tea per acre over unmanured check plots.					
	to end June.	July.	Aug.	Sept.	Oct.	Nov.	Total.
Single dose of 120 lbs. on March 15th ...	·65	·55	1·08	1·45	1·13	·48	5·34
2 doses of 60 lbs. each March 15th and June 15th	·47	·59	1·04	1·57	1·16	·44	5·27
3 doses of 40 lbs. each March 15th May 15th and July 15th ...	·41	·38	1·04	1·42	1·03	·47	4·65

Again the effect of reducing the first dose is seen in reduced crops in the early part of the season.

With a total of 120 lbs. nitrogen per acre it again makes little difference to the total increase for the season, whether the manure be added in one or two doses. With three doses however efficiency (in the first season) is lost. It is probable that the July dose is rather too late to exercise its full effect in the first season. It is possible also that the May dose, applied when the soil still contains a high content of nitrate from the March manuring, is too early for full efficiency.

Earlier experiments have indicated that in the long run. it makes little difference to total crop, whether manure be added in one single dose, or in several divided doses per season, so that it is probable that the small losses from divided doses will be found in the first year of manuring only. On general principles we consider it dangerous, from the point of view of quality to add too much nitrogen at one time. It will be seen that 80 lbs. nitrogen in one dose compared to two doses of 40 lbs. give nearly double the increase to the end of June. Up to this date there has been little time to produce more pluckable shoots per bush, and the greater part of the increase must come from

GRAPH No. 2.


Black line—No Manure
Red line—40 lbs. Nitrogen on March 15th
40 lbs. Nitrogen on June 15th
Green line—80 lbs. Nitrogen on March 15th only
Yellow line—40 lbs. Nitrogen on March 15th only
Lbs. green leaf per week from 630 bushes
60
50
40
30
20
10
Effect on weekly pluckings of single doses compared to divided dose.
8 12 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30 7 14 21 28 4 11 18 25
April
May
June
July
August
September
October
November

an increased rate of growth which is very likely to produce poorer quality. The later increases, from inspection of the bushes, clearly come very largely from increased size of bush and a greater number of plucking shoots.

The single dose of 120 lbs. per acre does not give much greater increase to the end of June than the single dose of 80 lbs. so that there can be no great increase in the rate of growth from the larger quantity: the increased crop from the greater quantity comes later in the season when more shoots are plucked. It might be considered therefore that there may be no greater danger to early quality from one dose of 120 lbs. than from one dose of 80 lbs. Yet this is by no means certain. It is probable that an increased nitrate content of the soil, which does not produce increased crop, may influence the composition of the shoots more than an increase which produces marked increased of crop.

It will be seen from Graph No. 3, facing this page, that the effect of increasing doses on crop to the end of June, becomes increasingly less than proportional to the quantity of nitrogen applied, when more than 40 lbs. nitrogen is applied.

On the whole we consider that spring doses exceeding 40 lbs. per acre of soluble nitrogen are better avoided until more information is available. Many gardens are very dependent, for average prices, on high prices for second flush teas. If, to the end of June, 2.4 mds. of tea were produced with 80 lbs. or 2.5 mds. with 120 lbs. nitrogen, and sold at 1*s*. 3*d*., instead of 2.1 mds. with 40 lbs. only, sold at 2*s*. the profit from the total increased crop might vanish. On many gardens no harm to second flush quality has been apparent after moderate manuring. On gardens where reduction of second flush quality is suspected after even moderate manuring in the spring, it is suggested that manures be withheld till June. Crop will be lost that year, (if bushes cannot be fully plucked in the rains) but not in future years if the June manuring be continued.

There is this also in favour of a dose of about 40 lbs. nitrogen. Both this series of experiments and earlier ones, indicate that up to about this quantity the increase in crop is proportional to the amount of manure applied, but there is some loss in efficiency from doses much exceeding 40 lbs.

If a total of much more than 40 lbs. nitrogen is to be applied, we think that for the present at any rate it will be safer to apply in two doses.

Effect of time of application of second dose.

Further experiments were made to determine the effect of the time of application of a second dose.

The following table shows the effect of applying a second dose of manure, supplying 40 lbs. nitrogen per acre, in May, June, and July respectively, in each case following a first dose of 40 lbs. on March 15th. The effect of the single dose on March 15th. is included to the same table for comparison.

lbs. nitrogen per acre.	crops in mds. tea per acre.						
	to end June	July	Aug.	Sept.	Oct.	Nov.	Total.
40 lbs. on March 15th ...	2·16	1·25	2·00	2·52	1·97	0·76	10·66
40 lbs. on March 15th } 40 „ on May 15th } ...	2·18	1·46	2·36	3·00	2·17	0·96	12·13
40 „ on March 15th } 40 „ on June 15th } ...	2·09	1·38	2 35	3·04	2·27	1·00	12·13
40 „ on March 15th } 40 „ on July 15th } ...	2·20	1·23	2·42	3·08	2·30	0·98	12·21

It will be observed that there is no significant difference in total crop due to the time of application of the second dose. Neither the May nor the June manuring have affected the crop to the end of June. The July crop is increased significantly by the May manuring, and slightly by the June manuring, but these differences are made up by later slightly greater increases from the later manuring.

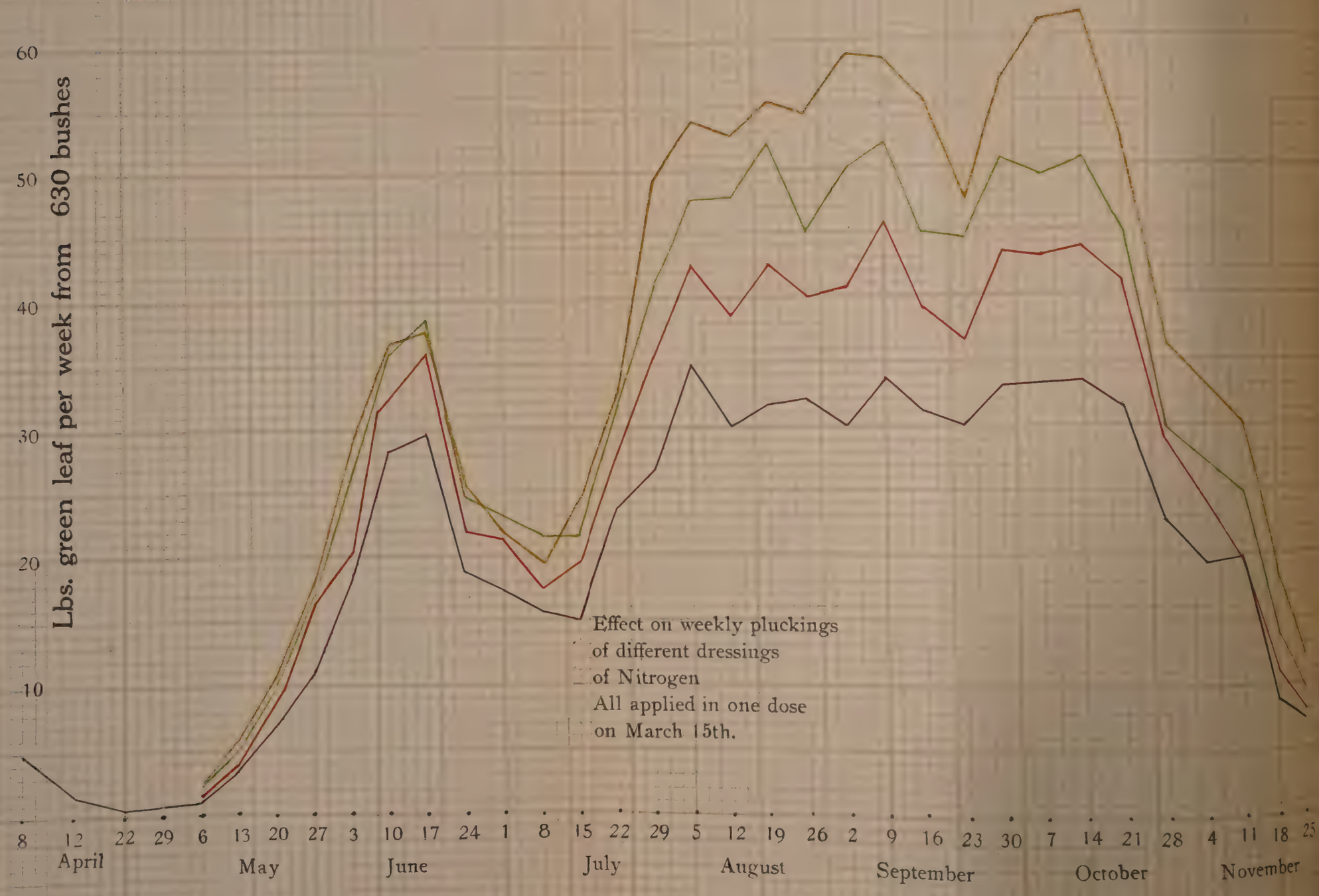
GRAPH No 4.

Black line --No Manure

Red line — 40 lbs. Nitrogen per acre on March 15th

Green line - 80 .. ..

Yellow line - 120 .. ..



Since the later time of manuring is likely to give slightly greater residual effect next year, one would expect that some time towards the end of June, or in early July, would prove the best for the second dose, but there is little in it.

This, of course, only applies to the case of normal manuring for crop where there is ample labour in the rains to pluck it.

Where a weak area is to be forced through, or where a short laboured garden requires early crop from a particular area, the total dose decided on should be given in February or March; but total applications of 80 lbs. nitrogen per acre will rarely be considered on short laboured gardens.

A most important point made clear by these experiments is the long lasting effect on crop from a soluble manure like sulphate of ammonia. The following table shows the crops plucked monthly after various doses of manure applied all on March 15th.

lbs. nitrogen per acre applied March 15th	mds. tea per acre.						
	to end June	July	Aug.	Sept.	Oct.	Nov.	Total
nil	1·79	1·00	1·58	1·94	1·47	·70	8·48
40	2·16	1·25	2·00	2·52	1·97	·76	10·66
80	2·37	1·42	2·36	2·99	2·18	·93	12·25
120	2·44	1·55	2·66	3·99	2·60	1·18	13·82

These differences are better shown in Graph No. 4, facing this page.

It will be observed that the increases in October are rather greater than they are to the end of June; while even on the small autumnal growth of November, 1930, the effect of the manure applied in March is quite marked.

The soluble manure does not, as is often popularly supposed (judging from the colour of the bushes) exercise an enormous effect soon after application and then cease to function, but produces a steadily increased crop throughout the

season. This point was noticed last year in the case of other plots * when it was noticed that it was the more remarkable since the nitrate produced by manuring left the surface soil within three months of manuring. It was then pointed out that unless soluble nitrogen were stored in the subsoil, the late increases in crop must be due to the effect on the bush of the increased nitrate content of the soil early in the season.

This year's results, quoted fully in the Annual Report (Chemical Branch) for 1930, show that there is no storage of nitrogen in the surface soil or in the subsoil, either as nitrate or as ammonia, after about May 21st. when only 40 lbs. nitrogen per acre are used. The effect on late crop therefore must be due to the effect on the bush of the increased nitrate content of the soil early in the season, and possibly due to storage of nitrogen in the bush.

When 80 lbs. nitrogen (as sulphate of ammonia) were applied, soluble nitrogen (nearly all as nitrate) continued high till much later in the season, as shown in the following table.

lbs. nitrogen per acre supplied as manure on March 15th	Average parts nitrogen as nitrate per million parts soil							
	before March 15th		March 15th to May 21st		May 27th to July 16th		July 23rd to Nov. 30th	
	surface to 9" deep.	Subsoil 9" to 36"	Surface to 9" deep	Subsoil 9" to 36"	Surface to 9" deep	Subsoil 9" to 36"	Surface to 9" deep	Subsoil 9" to 36"
nil	3	1½	10	3	2	1½	2	1
40	3	1½	27	6	6	2½	2	1½
80	3	1½	32	8	21	11	4	2

Summary and Discussion of Results.

It will be observed from the curves (Graph No. 1) that at 120 lbs. nitrogen per acre, the rate of increase of crop with increasing nitrogen is still rising sharply, whether single or divided doses of manure be used. 120 lbs. nitrogen per acre for most crops would be considered a very large dose, yet it is clear that for this particular tea, at any rate, it is not anywhere

* Quarterly Journal, 1930, Part II, p. 57.

near the useful limit as far as crop production is concerned. This tea which, unmanured, gives 8½ mds. tea per acre could have been made to give very much more than 14 mds. per acre by the use of quantities of nitrogen per acre exceeding 120 lbs. These increases in crop are very remarkable and indicate the great dependence of the tea bush on supplies of available nitrogen from the soil.

Where nitrogen is naturally abundant, as on the very rich *humus* soils of drained *bheels* in the Surma Valley, crops exceeding 20 mds. tea per acre are common, while the soil remains in good physical condition. Very high yielding tea such as occurs on an experimental area at Borbheel (Bishnath, Assam), has been increased in yield from about 18 mds. per acre to 21 mds. by the use of 30 lbs. of available nitrogen per acre. On other areas of the naturally poor soils of Tocklai and Borbhetta crops of 20 mds. per acre have been maintained by heavy manuring for several years; and these do not, so far, show any indication of undue liability to disease.

The large increases in crop obtained in this experiment are therefore not abnormal: and the enormous possibilities of big crop production by heavy manuring are of great interest.

No undue alarm need be felt concerning the possibility of any such enormous increases, from the tea districts generally, as are here shown to be possible. Most gardens now have insufficient labour to take all the leaf which their bushes are capable of giving under present conditions. In such cases any increase in the yielding capacity of the bushes (from manuring) would give increased crop in the early part of the season while the labour could cope with it, and no more during the heavy flushing months when nearly all the crop is made. Possibly even less crop might be made as very leafy heavily manured bushes would become very high if underplucked and tend to go *banjhi*.

Under such circumstances the utility of such experiments as these, at the present time, may be considered doubtful; but

apart from the fact that all knowledge is useful, there are occasions when big doses may be desirable even at the present time, (for example on areas which are deteriorating) and it is very necessary to know the probable effect of any particular dose.

Much more important however, is the question of cost of production. These experiments show that, roughly, for an additional 40 lbs. nitrogen per acre about 2 mds. extra tea are obtained.

The cost of the manuring to produce this effect, at Tocklai, is :—

	Rs.	A.	P.
200 lbs. sulphate of ammonia @ Rs. 134/- per ton	11	15	0
100 ,, ordinary superphosphate @ Rs. 65/- per ton ...	2	14	0
40 ,, sulphate of potash @ Rs. 165/- per ton	2	15	0
340 lbs.	17	12	0
Freight on 4¼ mds. @ -/12/- ...	3	3	0
Carting	0	9	0
Application	2	0	0
Total ...	23	8	0

After this expenditure the additional crop obtained still has to be plucked, manufactured, boxed, and transported to market. It is extremely difficult to obtain accurate figures for the sum of these costs on any garden. Estimates vary from Rs. 6/- to about Rs. 20/- per md. If the increased crop bears its fair share of factory and recruiting costs, the highest figure is probably the most accurate. The additional 2 mds. of tea then costs Rs. 23/8/- for manuring and Rs. 40/- for harvesting and marketing costs, or a total of Rs. 63/8/- for 160 lbs. tea. In that case the extra tea is produced for 6 annas 4 pies per lb. In Upper Assam generally, using shade trees, green crops, and moderate manuring, about 9 mds. tea per acre were produced in 1929 for an average cost of about 10 as. per lb. or Rs. 450/- per acre—often more and rarely less.

The use of an additional 40 lbs. nitrogen per acre would be expected to produce 11 mds. per acre, for a cost of Rs. 513/8/- per acre, or 9 as. 4 pies per lb., instead of 10 as. Increased

manuring therefore would be expected to show not only increased profit per acre, but increased profit per lb. so long as prices did not suffer on account of reduced quality of the product. This last point was dealt with in the previous issue of this Journal, where the opinion (on such evidence as is available) is given that no significant fall in quality need be feared so long as plucking is fine and at close intervals.

In districts where cost of production is greatly less than 10 as., the harvesting, manufacturing and marketing costs will also be less. Similar considerations therefore apply, but with less force since many of the items in the total cost (e.g. manuring, boxes, fuel) will be much the same in any district; and in some districts an increased crop from manuring approaching 6 as. per lb. in cost, would leave little margin for profit at present.

If crop were increased, by manuring, only up to the capacity of a labour force and factory accommodation previously in excess, than the cost of the increase would be much less than 6 annas per lb. and must pay heavily on any market.

Such increased crops, of course, cannot be taken in any district while crop is restricted by agreement; and while restriction continues there may still appear to be little use for relatively heavy manuring.

The further opinion, however, is ventured that manuring has in some cases been used to improve quality, by making the same crop as with lesser manuring but plucking more finely and at closer intervals.

More leaf of the same quality, can be plucked per cooly from a small area of high yield than from a large area of low yield. Areas of big bushes also require less labour per acre for cultivation, and less labour per lb. of tea for pruning. It is possible therefore that in many cases, a reduction in cost per lb. of tea can be effected by the abandonment (temporary or permanent) of poor areas, and the manuring of better areas to make up the difference.

Even at the present time, therefore there may be some use for relatively heavy manuring, to produce the same crop as with lesser manuring, but producing a better class of tea, at a lower cost per lb.

It would be extremely difficult to give generally applicable advice on such a point. Each particular case would have to be considered carefully, but to make such consideration possible the information obtained in these experiments is a necessity. It may be asserted however, that there is no hope of improvement of quality from nitrogen manuring, except where abundance of labour exists. In those cases where marked improvement is believed to have been made by this means, it has been made possible by the better employment of a labour force approaching two coolies per acre. In cases where the crop is limited not by the yielding capacity of the bushes, but by the labour available to pluck, manuring can only reduce quality without increasing crop (except in the early part of the season), because coarser leaf would have to be plucked to keep the bushes within control. Short laboured gardens, therefore, cannot be expected to take much immediate interest in the results of these experiments on heavy manuring.

Others more fortunately situated must give these results serious consideration. These results may be summarised.

1. Compared to the same tea unmanured, a single dose of 40 lbs. nitrogen, in available form, may be expected to produce an increase in crop of about 2 mds. *pucca* tea per acre, in the first year.

From results of experiments elsewhere, and from general experience, this increased is believed to be what may be expected from normally healthy tea in the first year of manuring. Badly diseased bushes, of course, cannot be expected to make full use of an increased food supply.

The increased crop will not always show up against the yield of the previous year. For example in the series of ex-

periments here discussed, the plots receiving 2 doses of 20 lbs. nitrogen gave in 1930, 10.1 mds. tea against 9.8 mds. in 1929 when unmanured. The check plots unmanured in both years which also gave 9.8 mds. in 1929 only gave 8.5 mds. in 1930. The drop was due partly to climatic factors, and partly to increasing deterioration from deficiency of plant food in the unmanured soil.

The real increase due to the manure was the increase over the check plots in 1930, or 1.6 mds. and not the increase over the previous year's yield or 0.3 mds. only.

When considered against yields in the previous year or years, results from manuring often appear disappointing: but even in such cases one may rest assured that the results are better than they would have been had no manure been used. This of course assumes that all the leaf grown is plucked. This means that bushes must be plucked closely and regularly. Where leaf is left on the bushes, results from manuring will appear disappointing. Manured bushes must in that case benefit from the extra leaf left on them, but that benefit may take a very long time to show up in yield.

2. In the case of total applications up to about 40 lbs. nitrogen per acre it does not pay to divide the dose.

3. Each additional 40 lbs. nitrogen up to 120 lbs. nitrogen per acre at least, whether applied in one or in two doses, may be expected to give additional increased crop of about 1.6 mds. tea per acre.

4. Although it makes no difference to total crop whether doses of 80 and 120 lbs. nitrogen be applied in one dose or in two, it is advised, for the present, that doses of not more than 40 lbs. nitrogen per acre be applied at one time. This is from fear of undue loss of quality.

5. It makes no significant difference to total crop whether the second dose of manure be applied in May, June, or July. Late June or early July probably offers a slight advantage over earlier application, but there is very little in it.

6. The effect on crop even from large quantities of soluble manure like sulphate of ammonia, lasts throughout one full season at least.

Experimental Details.

The tea is of Mesai Manipuri variety, planted $4\frac{1}{2}' \times 4\frac{1}{2}'$ triangular with one-year old plants at the end of 1922. It was allowed to grow unpruned and unplucked till cut across at 18", with light taking out of centres, in November, 1924. Since then it has been top-pruned.

In 1926 the area was divided in 70 sub-plots containing 90 bushes each, the area of each sub-plot being .0362 acres (about 1/25 acre). The yields proving irregular in that year, the plots above average were left unmanured, while the poorer plots received 5, 10 or 20 tons cattle manure per acre according as they were little or much below average, and were left unplucked from the end of September. In 1927, 1928, and 1929 all were plucked and treated alike: yields for each sub-plot still being recorded separately.

It was required to try the effect of ten different treatments, so that the use of 70 sub-plots allowed each different treatment to be tried on 7 sub-plots, which was considered a sufficient number of repeats.

Previous trials with hap-hazard selection of plots have not given concordant results. It is suggested also that, where the previous history of the same plants in the same soil is known, a considered selection would better eliminate the disturbing effects of differences in soil and in condition of bushes. The problem was to select ten teams (or series) of 7 plots each, such

that the yield of each team of seven would be likely to be the same in future years if treatment for all continue the same.

The selection was made in the following manner. The 70 sub-plots were divided into 7 blocks of ten plots each, so that the previous history of the plots in any one block was as nearly as possible the same.

On the accompanying plan, these seven blocks are shown bounded by heavy black lines.

Plots within the same block are therefore fairly comparable with each other.

Ten series of 7 plots each were then selected so that each block contained one plot of each series; and, also, so that the total yield of each series had been as nearly alike as possible in 1929, and in 1928.

One further limitation was imposed. The plots of 9×70 bushes are divided by paths (a line of tea being left unplanted between each plot) so that with regard to boundaries between plots all sub-plots are equal in respect to "edge-effect". On the north and south sides there are roads. Road-side bushes (where as in this case there is no drain between the road and the tea) benefit from extra food obtained from under the road. These road-side sub-plots therefore have an advantage of position over the inside sub-plots, which are divided simply by low *bunds*, with no line of tea missed. There are ten sub-plots on each road-side. Plots were so selected that one plot of each series occurred along each road-side (see plan).

The following were the aggregate yields of each series in 1928 and 1929. Yields for 1926 are also included to show that, even so far back, the aggregate yields from the series selected were not greatly different. The difference in 1926 between the highest and lowest yielding series is 24 lbs. or 4%.

Yields in lbs. leaf per 630 bushes.

	1929.	1928.	1926.
Series, 1.	786	741	597
,, 2.	794	732	603
,, 3.	791	734	589
,, 4.	792	746	612
,, 5.	792	735	607
,, 6.	792	745	613
,, 7.	790	733	611
,, 8.	791	744	594
,, 9.	795	738	604
,, 10.	794	739	590

These ten teams (or series) have therefore been carefully chosen to have practically the same aggregate handicap. The allotment of the various treatments to different series was made by chance. It may be expected that series so chosen would have continued to yield similarly in future years if treatment had remained the same, and that differences found, after treatment, result from the treatment given.

The results quoted have proved to be very fairly concordant. The accuracy of the results may be further examined by considering the behaviour of the individual plots within each series, comparing the yield of each plot in 1930, with the yield from the same plot in 1929 when all were unmanured.

SERIES 1.

No Manure.

Block No.	Sub-plot No.	Yield in lbs. and ozs green leaf.		
		1929.	1930.	difference.
1.	255c	101-0	86- 8	—14- 8
2.	261a	111-1½	93- 2½	—17-15
3.	263b	110-6	84-13½	—25- 8½
4.	262f	111-5	102-15½	— 8- 5½
5.	263g	126-6½	109- 4	—17- 2½
6.	258f	122-4½	111- 3	—11- 1½
7.	258e	103-1	100- 9	—12- 8
	Total ...	785-8½	688- 7½	—97- 1
			Average *loss* per plot compared to 1929 :—	13lbs. 14 ozs.

Series 2.

40 lbs. nitrogen in March, 1930.

Block No.	Sub-plot No.	Yield in lbs. and ozs. green leaf.		
		1929.	1930.	difference.
1.	257c	108- 6	115-15½	+ 7- 9½
2.	259a	121-15½	133- 8	+11- 8½
3.	260d	108- 2	117- 8	+ 9- 6
4.	262e	109- 3	120- 8	+11- 5
5.	259g	116- 2½	129-14½	+13-12
6.	255e	126-15	128-15	+ 2- 0
7.	257e	103- 1	118-14½	+15-13½
	Total ...	793-13	865- 3½	+71- 6½
			Average *gain* per plot compared to 1929 :—	10 lbs. 3 ozs.

Series 3.

80 lbs. nitrogen in March, 1930.

Block No.	Sud-plot No.	Yield in lbs. and ozs. green leaf.		
		1929.	1930.	difference.
1.	256c	89- 7½	115- 9	+26- 1½
2.	260a	122- 0½	153- 2½	+31- 2
3.	260c	96- 0½	125-11	+29-10½
4.	263e	124- 1	151-13	+27-12
5.	259f	122- 7½	153-15½	+31- 8
6.	255g	121- 3	147- 3½	+26- 0
7.	258d	115- 6	147- 3	+31-13
	Total ...	790-10	994- 9½	+203-15½
			Average *gain* per plot compared to 1929 :—	29 lbs. 2 ozs.

Series 4.

120 lbs. nitrogen in March, 1930.

Block No.	Sub-plot No.	Yield in lbs. and ozs. green leaf.		
		1929.	1930.	difference.
1.	258b	97- 8	153- 6	+55-14
2.	258a	121- 2	178- 6½	+57- 4½
3.	261d	108- 6	153- 3	+44-13
4.	264d	110- 1	150-10	+40- 9
5.	264f	113- 9	146- 7	+32-14
6.	258g	133-11	173- 8	+39-13
7.	257d	107-11	166- 8	+58-13
	Total ...	792- 0	1122- 0½	+330- 0½
			Average *gain* per plot compared to 1929 :—	47 lbs. 2 ozs.

Series 5.

20 lbs. nitrogen in March and 20 lbs. in June.

Block No.	Sub-plot No.	Yield in lbs. and ozs. green leaf.		
		1929.	1930.	Difference.
1.	256b	89- 8½	90- 0	+ 0- 7½
2.	263a	120- 7	120- 0½	− 0- 6½
3.	260e	103-12	118- 6	+14-10
4.	264c	113- 4½	114-11½	+ 1- 7
5.	264g	130- 6½	139- 0½	+ 8-10
6.	257f	122- 5½	124-11½	+ 2- 6
7.	258c	112-12	116-10½	+ 3-14½
	Total ...	792- 8	823- 8½	+31- 0½
			Average *gain* per plot compared to 1929 :—	4 lbs. 7 ozs .

Series 6.

40 lbs. nitrogen in March and 40 lbs. in June.

Block No.	Sub-plot No.	Yield in lbs. and ozs. green leaf.		
		1929.	1930.	Difference.
1.	255b	89- 0	113-12½	24-12½
2.	262a	119-10½	151-11	32- 0½
3.	262b	106- 6½	135-11	29- 4½
4.	263f	108- 4½	128- 1	19-12½
5.	261g	134- 8½	166- 3½	31-11
6.	256f	122- 6	140-15½	18- 9½
7.	256d	112- 1	148- 2	36- 1
	Total ...	792- 5	984- 8½	192- 3½
			Average *gain* per plot compared to 1929 :—	27 lbs. 7 ozs.

Series 7.

60 lbs. nitrogen in March and 60 lbs. in June.

Block No.	Sub-plot No.	Yield in lbs. and ozs. green leaf.		
		1929.	1930.	Difference.
1.	257b	95-14	143-14	48- 0
2.	264a	111-10	165- 6½	53-12½
3.	261b	109- 4½	152- 1	42-12½
4.	263d	105- 0	141-13	36-13
5.	260g	137-14½	177-14	39-15½
6.	256e	117- 3	163-12	46- 9
7.	259e	113- 7	171-14½	58- 7½
	Total ...	790- 5	1116-11	326- 6
			Average *gain* per plot compared to 1929 :—	46 lbs. 10 ozs.

Series 8.

40 lbs. nitrogen in March and 40 lbs. in May.

Block No.	Sub-plot No.	Yields in lbs. and ozs. green leaf.		
		1929.	1930.	Difference.
1.	255a	101- 5½	124-12½	23- 7
2.	264b	121- 7½	141- 6	19-14½
3.	261c	99- 0½	137-14	38-13½
4.	262d	110- 1	139-13	29-12
5.	261f	113- 5½	144- 8½	31- 3
6.	257g	130- 0½	159-14½	29-14
7.	255d	115-14	136- 7½	20- 9½
	Total ...	791- 2½	984-12	193- 9½
			Average *gain* per plot compared to 1929 :—	27 lbs. 10 ozs.

Series 9.

40 lbs. nitrogen in March and 40 lbs. in July.

Block No.	Sub-plot No.	Yields in lbs. and ozs. green leaf.		
		1929	1930	difference.
1.	256a	89-15½	120-10½	30-11
2.	260b	118- 9	142-13½	24- 4½
3.	262c	104- 3	127-15½	23- 8½
4.	264e	118-15½	146- 5½	27- 6
5.	260f	134- 7	165- 8½	31- 1½
6.	256g	120-12½	146- 1	25- 4½
7.	259e	108- 5	142- 5	38- 0
	Total ...	795- 3½	991-11½	196- 8
			Average *gain* per plot compared to 1929	28 lbs. 1 oz.

Series 10.

40 lbs. nitrogen in March, 40 lbs. in May, and 40 lbs. in July.

Block No.	Sub-plot No.	Yields in lbs. and ozs. green leaf.		
		1929	1930	diefference
1.	257a	83-11	134- 4½	50- 9½
2.	259b	116-11	160-10	43-15
3.	261e	109- 2½	146- 9	37- 6½
4.	263c	115-14½	160- 0½	44- 2
5.	262g	130- 9	165-13	35- 4
6.	255f	123-10½	142- 0	18- 5½
7.	259d	114- 4½	156- 9	42- 4½
	Total ...	793-15	1065-14	271-15
			Average *gain* per plot compared to 1929.	38 lbs. 14 ozs.

The following table indicates the nature of the agreement between the seven replicates of experiment.

Series.	Average gain in lbs. compared to 1929.	Greatest difference from mean.		Sum of squares of differences from mean gain (Sd^2)	Probable error of mean gain $\cdot 67\sqrt{\frac{Sd^2}{42}}$
		Below	Above		
1.	14 (loss)	11	4	330	1·9
2.	10	8	6	244	1·6
3.	29	3	3	40	0·7
4.	47	14	10	436	2·1
5.	4	4	10	167	1·3
6.	27	9	9	268	1·7
7.	47	10	12	364	2·0
8.	28	8	11	277	1·7
9.	28	5	10	157	1·3
10.	39	20	12	536	2·4

The probability is that seasonal differences due to situation, unavoidable differences in pruning and plucking, and other factors which may affect one plot as compared to the average, lead to an error in observation of the yield of any one plot in one year, which rarely exceeds 6 lbs. of leaf (about 5%). Thus if the yield observed on one plot is 6 lbs. too little in 1929, and

6 lbs. too much in 1930 the difference between the yields of that plot in the two years would be 12 lbs. more than the average difference. If the error were so great as 6 lbs., it would not often affect the same plot in opposite directions in succeeding years. Differences from the mean, of 12 are found in 3 cases, of 14 in one case, of 10 in 4 cases, and 9 in 3 cases, while in one abnormal case (which cannot be explained at present) a difference of 20 occurs.

The probable error of the mean gain can be used to test the significance of differences in gain in cases where the difference is small.

Thus :—

Series 2. (40 lbs. nitrogen in dose) has an average gain of 10.2 lbs. per plot. P.E. of average gain = 1.6.

Series 5. (40 lbs. nitrogen in two doses) has an average gain of 4.4 lbs. per plot. P.E. of average gain = 1.3.

The true average gain of series 2 is probably not below 8.6, and the true average gain of series 5 probably not above 5.7, so that it is probable that the treatment of series 2 has been more effective than that of series 5.

Without invoking mathematics the significance of the difference between the effect of the treatment of series 2, and that of series 5 may be estimated by comparing the relative gains by the pairs of plots within each block.

Gain compared to 1929 to nearest lb.

Block No.	Series 2.		Series 5.	
1.	257c	8	255b	0
2.	259a	12	263a	0
3.	260d	9	260e	15
4.	262e	11	264c	1
5.	259g	14	264g	9
6.	255e	2	257f	2
7.	257e	16	258c	4
aggregate ...		72		31

In Block 3 series 5 scored a win, (plot 260 e was much above previous form :) the match in Block 6 resulted in a draw : in the other 5 blocks, series 2 wins very easily.

The treatment of series 2 again appears to have been significantly better than that of series 5.

The significance of the apparent difference in the results from series 10 compared to series 7 may be similarly estimated.

Series 7. 120 lbs. nitrogen in two doses.
gains 47 lbs. P.E. = 2.0.

Series 10. 120 lbs. in three doses.
gains 39 lbs. P.E. = 2.4.

The observed difference between the two gains is 8 lbs.

The true gain of series 7 is probably not below 45 lbs., and the true gain of series 10 probably not above 41.4 lbs., so that it is probable that the treatment of series 7 has been more effective than that of series 10.

Comparing the relative gains of the pairs of plots within each block :—

Gains to nearest lb.

Block No.	Series 7.	Series 10.
1.	257b 48	257a 51
2.	264a 54	259b 44
3.	261b 43	261e 37
4.	263d 37	263c 44
5.	260g 40	262g 35
6.	256e 47	255f 18
7.	252e 58	259d 42
aggregate ...	327	271

It will be seen that series 7 wins in 5 out of 7 blocks, and therefore the observed superiority is probably significant; but the magnitude of the difference between the aggregates is probably somewhat exaggerated by the unexplained failure of plot 255 f to play up to form.

THE USE OF ACIDIFIED E.C. IN FACTORIES.

By

S. F. Benton.

In a previous article, (Quarterly Journal, 1930, Part IV pp. 163—169) the use of a hot solution of Electrolytic Chlorine was advised for the purpose of cleaning and sterilising the floors in the factory. Although this method has proved greatly superior to the use of plain water, permanganate of potash, or steam, several objections have arisen in practice.

Firstly, the necessity of using a hot solution results in a considerable amount of extra work and, unless preparations have been made beforehand, delay.

Secondly, although the solution is at the correct temperature when applied to the floor, it is immediately chilled, and when in this state its activity is much reduced. This is most noticeable when heavy deposits are being dealt with, the difficulties in this case being such as to promote the suggestion that the major portion of the dirt be scraped away with knives before the final operations commenced.

Finally there is the question of the alkaline reaction of Electrolytic Chlorine, which in some instances has been suspected of causing a blackening of the leaf in contact with the floor. This defect is only brought about by incorrect application, *e.g.*, by flooding the floor with the solution and allowing the tea residues to absorb alkali, or by failure to wash the floor down after completion of the treatment. The details of these cases always show that the above errors have been made, and that the E.C. treatment has been adopted more as a magic rite than as a practical and scientific method of *cleaning* a floor. Nevertheless, in practise it is not always possible to give adequate supervision, and there is always a chance of poor results if the conditions of the old method are not strictly adhered to.

A modification has now been introduced which avoids these objections, and at the same time, accelerates the cleaning process

to a remarkable degree. The solution is used cold and the alkalinity is neutralised by the addition of a small amount of sulphuric acid.

Chemistry of the reaction.

The decomposition of tea residues by Electrolytic Chlorine is a result of oxidation. The essential principle of the reagent—sodium hypochlorite—does not exert an oxidising action itself, but passes through a series of changes. The first of these is the formation of free hypochlorous acid, through interaction with atmospheric carbonic acid :

$Na\,Cl\,O$	+	$H_2\,CO_3$	=	$H\,Cl\,O$	+	$Na\,H\,CO_3$
sodium hypochlorite.		carbonic acid.		hypochlorous acid.		sodium bicarbonate.

Free hypochlorous acid is unstable, and decomposes spontaneously, with the liberation of chlorine and oxygen :

$2\,H\,Cl\,O$	=	$H_2\,O$	+	Cl_2	+	O
hypochlorous acid.		water.		chlorine.		oxygen.

Part of the oxidising effect occurs at this stage, and the chlorine exerts a further effect by interaction with water :

Cl_2	+	$H_2\,O$	=	$2\,H\,Cl$	+	O
chlorine.		water.		hydrochloric acid.		oxygen.

The last two equations probably do not represent the full series of changes which take place after the hypochlorous acid has been formed, but in any case the final result is the production of "nascent", or highly active, oxygen which decomposes the tea residues.

The decomposition of hypochlorous acid and the subsequent changes take place almost instantaneously. It is therefore clear that, when using an alkaline solution, the speed of the whole reaction depends on the rate of absorption of carbonic acid from

the air. If however, the solution is acidified, the reaction is no longer dependent on this factor, and in consequence the liberation of active oxygen is effected immediately.

Method of using acidified E. C.

Determinations made in the laboratory have shown the amount of acid required to be small. It is not necessary, for factory conditions, to adhere to exact amounts provided that sufficient acid is used to neutralise the solution. In practise the following method has been found most convenient.

To a kerosine tin of cold water *i.e.*, approximately four gallons, is added half an ounce of battery acid, and immediately before use, four ounces of Chlorion (see below). The solution is well stirred and brushed into the floor with ordinary English-pattern scrubbing brushes until the cement surface is exposed, which normally requires five to ten seconds, even on heavily coated floors. The separated dirt should be washed off the floor as the work proceeds, and when the whole floor has been cleaned it should be washed down with E.C. to effect a final sterilisation and subsequently with clean water to remove all traces of dirt, chlorine, etc.

The same treatment should be accorded to the floor in the rolling room, to the leaf trollies, and in short to all places with which the leaf comes in contact during manufacture. (Note: battery acid is composed of concentrated sulphuric acid one part, water two parts).

Among the advantages of the new method, three will appeal to the practical man. The use of a cold solution is of convenience since the treatment may be carried out without previous preparation. The reaction is greatly accelerated by acidification. The time required for the decolourisation of a suspension of tea residues in water is :—

Alkaline E.C. 70° F.	30 minutes.
Alkaline E.C. 140° F.	5 ,,
Acid E.C. 70° F.	2-5 seconds.

Allied to this feature is the completeness of the attack on heavy deposits. A layer of an eighth of an inch in thickness has been found capable of removal in a few seconds by simple brushing, and no drastic methods appear to be necessary except in the most extreme cases. Finally the use of an acid solution avoids the danger of blackened leaf and dull infusions if a little of the solution be accidentally left on the floor.

Variation in Chlorine content of samples.

Analysis of various proprietary brands of E.C. have shown wide variations in available chlorine content, and furthermore some samples have been found to contain lime, added with the intention of minimising the loss of chlorine which is liable to occur during storage, more particularly in countries where high temperatures rule. The presence of lime is highly undesirable on floors in the factory, so that a product which has been stabilised in this manner is to be avoided. One of the samples was claimed to contain 25% available chlorine—a highly misleading but very convenient misprint for 2.5%. Details of typical analysis are given below :

Sample	*% available chlorine*	*Remarks*
E.C. (1)	1.17%	Stabilised with lime.
E.C. (2) (25% chlorine)	2.3 %	,, ,, ,,
Chlorion	6.0 %	Free from lime.

The low chlorine content and added lime in the first two samples, which were of Indian manufacture, is noteworthy. Chlorion is the most satisfactory of the products yet examined on account of its high chlorine content. The method of preparing the cleaning solution, given above, is based on the use of Chlorion. If low chlorine products are to be used the amount of E.C. should be increased to 2-3 ounces per gallon of water.

THE SIBSAGAR DISTRICT.

Soil Survey.

By

C. R. Harler.

Geography and Geology.

The Sibsagar division occupies the area generally spoken of in tea as Middle Assam, and is situated between the Naga Hills and the Brahmaputra. It falls into three sub-divisions, Golaghat, Jorhat and Sibsagar. Golaghat joins the Nowgong division and includes the greater part of the Mikir Hills and the valley of the Dhunsiri. The Jorhat sub-division lies between Golaghat and Sibsagar, extending from the Kakadanga to the Jhanzi River and taking in most of the Majuli, a great island formed by the Brahmaputra and the Kheriketia Suti. The Sibsagar sub-division extends from the Jhanzi to the Lakhimpur division. From one end of the Sibsagar division to the other is about 150 miles.

The Sibsagar sub-division consists of a plain varying from 20 to 30 miles in width, stretching from the Naga Hills to the Brahmaputra. Near the big River is a belt of country from three to seven miles wide which is annually flooded. This country is covered with high reed jungle interspersed with swamps or *bheels*. There is little cultivation in this tract except that of summer rice followed by pulse or mustard. The marshes and sandy *churs* left by the river, form grazing land for buffaloes.

Away from this low lying tract the country is mainly occupied by village cultivation or by tea. The latter is put out on

References—Allen, B.C., Assam District Gazetters, Vol. 7. Sibsagar (1906).
Mann, H. H. The Early History of the Tea Industry in North East India, *Bengal Economic Journal*, Calcutta (1918).

bams or banks which stand a few feet above the level of the rice land, and on the lowest slopes of the Naga Hills. Between Sonari and the Dehing are considerable stretches of jungle which are now being opened up. The stumps amongst the rice testify to the newness of these clearances.

The Naga Hills, except where the land is under *jhum* cultivation, are clad with heavy jungle.

The drainage of the Sibsagar sub-division is by means of rivers running in a westerly direction to the Brahmaputra which, in this area is flowing southwestward. The Dehing river, which for some miles of its course forms the boundary between Sibsagar and Lakhimpur, is the biggest. Next to the Dehing is the Disang, a river with a course of 136 miles, flowing in a deep channel and not changing its course, although it often overflows its banks. The Dikho, which flows through Nazira and Sibsagar, and the Jhanzi are the other two most important rivers. The general fall of the country is to the southwest, and on this account there is a tendency for the rivers to move westwards and flow parallel to the Brahmaputra when they reach the low lying belt near that river.

For a brief outline of the general geology of the Brahmaputra Valley, reference should be made to an article on the Lakhimpur district (this Journal, pt. III, 1929, p. 103). It is sufficient here to state that the Brahmaputra plain mainly consists of what is termed geologically as new alluvium. Banks of old alluvium, *e.g.*, the Bishnath Bank, occur. The new alluvium is composed of deposits which have been made at successive periods, mainly by the Brahmaputra and to a less extent by the rivers coming from the Naga Hills, as the floor of the valley has been lowered.

Near the Brahmaputra the soil is usually sandy, grey in colour and often a very recent deposit. Away from the River banks of stiff, reddish alluvium occur which are older than the

grey sands. The distinction between new alluvia is a subject enlarged upon later.

The tea soils formed *in situ* on the lower slopes of the Naga Hills are lateritic and closely related to the soils of Cachar. These soils overlie sandstone rocks of the Upper Teriary period, belonging to the Tipam geological series.

Development of the tea Industry in Sibsagar.

The tea industry in North East India may be said to have begun in Sibsagar. In 1823, R. Bruce, an adventurer and trader, visited Garhgaon, near Sibsagar, for trading purposes and, having heard of the existence of tea plants in the neighbouring district from a Singpho Chief, made arrangements to obtain some specimens. These were planted in Sadiya in 1825 by C. A. Bruce, Brother of the trader. These plants were not identified. In 1834, after the appointment of a committee by Government to consider the possibility of growing tea in India, plants were found near Sadiya by Lieut. Charlton, which were identified as of the same species as the China tea plant. Our industry may be said to start from this date (Nov. 8th. 1834), and is hence approaching its centenary.

A general account of the development of the tea industry in Assam is given in a previous Journal (pt. III, 1929, p. 105). Further reference may now be made to the subject, since the early history of tea in India is intimately connected with the Assam Company, which has its present holdings in the Sibsagar sub-district and head-quarters at Nazira.

In 1836, R. Bruce was made Superintendent of the Government Tea Forests in Assam, and the cultivation and manufacture of tea then started. In 1838, the first tea made from Assam indigenous bushes was successfully sold in London, and in the following year The Assam Company was formed. In 1840, two-thirds of the Government experimental tea areas were handed to the Company and Bruce joined them as Superin-

tendent of the Northern Division, with headquarters at Jaipur. A man named Masters was made Superintendent of the other division, with headquarters at Nazira.

The earliest trouble was lack of labour which was not obtainable locally in sufficient quantity. Large numbers of Chinese were imported first, the supposition being that every Chinaman was capable of cultivating, manipulating and preparing tea. The experiment was a failure and the Chinese were described as "turbulent, obstinate and rapacious". Labour recruited from India also proved unsatisfactory, largely on account of the unhealthy nature at that time of the country round Nazira.

In spite of these troubles the Company had 2,638 acres under tea in production in 1841, although the number of plants per acre was only 457. Most of the area consisted of groups of tea plants found in the jungle and cut down for cropping. The total amount of tea produced in this year amounted to 10,712 lbs., but the cost of production was naturally enormous.

As might be anticipated, the first few years in the life of the Company witnessed many ups and downs. Owing to the isolation of the gardens from business headquarters in Calcutta, and also to lack of technical knowledge, many mistakes were made. Stephen Mornay as Manager in Assam and Henry Burkinyoung in Calcutta were appointed in 1847, and these men took the Company from the verge of failure to success and stability.

In 1848, the maximum crop per acre was 275 lbs. The biggest yield in those days was obtained in April and the season ended in September. The reason for this was that as soon as the leaf grew it was plucked, without giving any initial growth. The monthly outturn in 1848, was as follows.

March	...	...	10,269 lbs.
April	...	...	41,125 ,,
May	...	...	36,391 ,,
June	...	...	37,523 ,,

July	...	...	31,920 lbs.
August	...	...	26,079 ,,
September	...	...	19,345 ,,

In 1853, George Williamson, afterwards founder of the firm of Williamson Magor & Co., became the Manager in Assam, and W. Roberts, afterwards connected with the Jorehaut Company, became the Calcutta Managing Director.

Williamson realised the evil of the China plant and also recognised that tea must be allowed to grow before it is plucked. When he first put this latter discovery into practice, the Directors became alarmed because of the crop shortage in March and April, but the result at the end of the year was a remarkable increase in crop per acre. Thus the problem of how much leaf to leave before plucking was opened, and it is still the most difficult point to be decided by the Manager on any garden. Too much or too little growth means loss of crop, and the latter also injury to the bush. The tendency in the past has been to leave too much initial growth, and too many leaves after the first flush before plucking to the *janum*. Of recent years it has been shown that fully grown tea, if well manured, can be plucked on 4 or 6 inches initial growth and straight to the *janum* several years in succession with profitable results (see this Journal pt. II, 1929).

The original holdings of the Assam Company were extensive and included large areas in the Tingrai and Jaipur districts as well as land in Darrang (Singrie Purbut) and Cachar. The Tingrai and Jaipur areas were sold to the Northern Assam Tea Company in 1863, and the Cachar division to Mr. Grob in 1864.

With the sixties, the pioneering days of tea in Assam may be said to have finished, although stormy and perilous days for the industry were still ahead.

By 1859 many gardens had been opened up in the Sibsagar sub-district and in that year the following list was published by Col. Jenkins, then Governor-General of the North East Frontier of India.

Name of proprietor.	Factory.	Total acreage.	Acres cleared.	Tea produced in the season 1858-59.
	Mouzah Nazerah	181½		Total.
	Dhopabur Cherie	151½		623,249 lbs.
	Dubba	246½		
Assam Company at Calcutta.	Kateepoottee	220		
	Kacharie Pookhree	492½		
	Lingree Pookhree	1258¾		
	Deopanee	561½		
	Gelakee	135		
	Mowdhoomnee	246½		
	Roockang	313¾		
Mr. Geo. Williamson.	Singloo	260	25	
Mr. R. Spears	Khongeeah	1300		
	Nahorunee	667		
H. Jenkins, Esq.	Khowang	1178	30	

In the whole of the Sibsagar division about 5,227 acres were reported cleared and under tea in 1859. At the present time 99,279 acres are in bearing of which about one-third is in the Sibsagar sub-division.

The sub-division is divided into three Circles of the Indian Tea Association, *viz.*, Moran, Sonari and Sibsagar. Several of the gardens in the Moran district are actually in the Lakhimpur political area but, being south of the Dehing they are, for convenience, included in the Moran Circle.

The accompanying sketch map of the District is drawn on the same lines as the last few maps included in our soil surveys. The place names are given their official spelling which differs in many cases from that adopted by tea companies.

Climate of Sibsagar.

The climate of the Sibsagar sub-division is eminently suited to tea and is almost as good as that in the Dibrugarh district. The average rainfall in the early months of the year is plentiful and serious droughts are rare. The precipitation decreases slightly from the Lakhimpur end of the district to the other, as is shown in the table below taken from Government records compiled up to 1920.

The decrease lower down the Valley is very marked. At Tocklai (Jorhat) the average is 82.51 inches and at Golaghat 77.86 inches.

Table showing Rainfall in Sibsagar sub-division.

Station.	Sonari.	Nazira.	Amguri.
January ...	1·37 ins.	1·20 ins.	1·10 ins.
February ...	2·47 ,,	2·21 ,,	2·02 ,,
March ...	5·09 ,,	4·37 ,,	4·96 ,,
April ...	10·10 ,,	9·92 ,,	9·75 ,,
May ...	9·72 ,,	9·71 ,,	10·36 ,,
June ...	13·88 ,,	13·73 ,,	13·21 ,,
July ...	17·03 ,,	15·59 ,,	15·67 ,,
August ...	15·77 ,,	16·07 ,,	15·46 ,,
September ...	10·71 ,,	10·52 ,,	10·64 ,,
October ...	5·05 ,,	4·95 ,,	4·91 ,,
November ...	1·15 ,,	0·96 ,,	0·83 ,,
December ...	0·47 ,,	0·53 ,,	0·50 ,,
	92·91 ,,	89·76 ,,	89·41 ,,
No. of wet days	129	126	120

Maximum and minimum temperatures taken under standard conditions are not available for Amguri, Nazira and Sonari, but those for Sibsagar, 10 miles from Nazira, are shown below. These are fairly indicative of what may be expected throughout the district, although in a well shaded garden the maxima in the tea are somewhat lower, and the minima a little higher than those in the table. The temperatures at Sibsagar differ very little from those taken under standard conditions at Tocklai.

Table showing Average Temperature at Sibsagar.

	Maximum. °F.	Minimum. °F.
January	70.0	49.7
February	72.8	53.2
March	78.8	59.7
April	81.7	66.2
May	85.5	71.5
June	88.8	76.3
July	89.6	77.8
August	88.8	77.7
September	87.8	76.3
October	84.4	70.6
November	77.9	59.7
December	71.3	50.5

Sibsagar soil types.

Only a comparatively small number of soil analysis of gardens in the Sibsagar sub-division is available, actually 129. Most of these have been made during the past ten years. This is an advantage, not because the soil changes appreciably in a few years, apart from a decrease in the content of nitrogen and organic matter, but because our manner of sampling and some of our methods of analysis have been changed within the last decade.

The number of soil samples required from a garden naturally depends on the number of soil types on the garden. On a fairly regular area, about four analysis on 1,000 acres is sufficient. On gardens consisting of *teelas* and flats and of definitely different soil types, more are necessary.

The Sibsagar tea soils are the heaviest in the Brahmaputra Valley and although, as in other districts, the fine sand fraction is the biggest one, the clay content is generally above 20%, and coarse sand the smallest fraction. The table below shows an average soil and also serves to denote the method of nomenclature used by this Department in describing our soils.

Average Sibsagar Tea soil.

Fraction.			Fraction number.
Coarse sand	...	6 %	1
Fine sand	...	28 %	2
Silt	...	23 %	3
Fine silt	...	19 %	4
Clay	...	20 %	5

Soil class 2, 3, 5, 4, 1.

Each fraction is denoted by a number, by which it is called. Coarse sand is denoted by No. 1, fine sand by No. 2, silt by No. 3, fine silt by No. 4 and clay by No. 5. In denoting a soil class, the fraction numbers are put into a chain in the order of their magnitude. Then with the above soil, the fine sand fraction, denoted by No. 2, is the biggest and takes first place in the class chain. Silt, No. 3 fraction, is the next biggest and so takes second place. Similarly with the other fractions.

Although this system of nomenclature is a useful one it has obvious drawbacks. Thus a soil containing, say, 50% fine sand, 30% silt, 8% clay, 5% fine silt and 4% coarse sand, would also be included in the class 2, 3, 5, 4, 1. This latter example is a sandy loam, whereas the average Sibsagar soil shown on the table above is a clay loam.

The numerical nomenclature has never appealed to the planter, and in practice it is usual to divide soils into three main classes, sands, clays, and loams. The first two terms are self descriptive and a "loam" is a free working soil, mainly composed of fine sand with some clay.

For a more detailed soil classification the term "loam" may be qualified according to the predominence of the sand, silt or clay fractions. In the same manner the clay class of soil may be qualified by the predominence of the sand or silt present.

Any classification should be very broad to be useful. The table below shows a classification adopted in America; in which

the limits to the different fractions are so wide, that a soil can be classified by a man in practice by mere handling.

The sand includes both fine and coarse sand, and the silt both silt and fine silt fractions.

Soil class.	Limits of mechanical composition.		
	Sand.	Silt.	Clay.
	%	%	%
Sands	80-100	0- 20	0- 20
Sandy loams	50- 80	0- 50	0- 20
Silt loams	0- 50	50-100	0- 20
Loams	30- 50	30- 50	0- 20
Silty clay loams	0- 30	50- 80	20- 30
Sandy clay loams	50- 80	0- 30	20- 30
Clay loams	20- 50	20- 50	20- 30
Silty clays	0- 20	50- 70	30- 50
Sandy clays	50- 70	0- 20	30- 50
Clays	0- 50	0- 50	30-100

In the table below this classification is applied to average light and heavy soils from the three Circles of the Sibsagar sub-district. The light soil rarely occurs in Nazira and Sonari but is common in the Moran area.

Table showing mechanical constitution of average Sibsagar tea soils.

District.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Class.
	%	%	%	%	%	
Sonari ...	5	24	20	22	23	Clay loam.
	20	25	17	16	16	Loam.
Nazira ...	3	31	26	16	18	Clay loam.
	20	32	15	10	13	Sandy loam.
Moran ...	10	30	24	19	16	Loam.
	28	30	19	7	11	Sandy loam.

The only easily workable soils in the above table are the light ones. Samples of such occur at Deepling, Safrai, Dholebagan, Amgoorie, Rajabarie, Bhamun, Ouphulia and Teloijan.

In order fully to classify a soil some system which is based not wholly on the characteristics of the soil itself, but also on its relationship to other factors, such as geology, climate, natural vegetation or crops, is necessary. In the American method of soil classification the unit is the soil *type*, which is a combination of a *series* name and a *class* (texture) name. For example, Sassafras Loam is the type in which Sassafras denotes the series, and Loam the class.

The Sassafras soils have definite characteristics and are capable of bearing certain crops. Thus the soil type describes both the general and particular qualities of a soil.

In determining a soil series the following characteristics are used as a basis. The geological origin of the soil material, the mode of formation, the topographic position, drainage and profile. The profile describes the soil at one, two and three feet depths. The description includes the colour, chemical reaction (alkalinity or acidity), organic matter and texture at these depths.

So far as tea soils of North East India are concerned, we have a number of well defined series. Examples which may be quoted include the series known as the Dooars Red Bank, which are soils formed of detritus from Sikkim gneiss and further weathered *in situ*. Another series is the Mal Sand, an alluvial soil deposited from Sikkim gneiss, and common in the Terai, parts of the Dooars and in some Darjeeling valleys. The Grey Sandy Loams are alluvia formed from rocks of the Damuda series: such soils occur in the Dooars. The Red Sandy *Teela* is a series formed *in situ* from Upper Tertiary sandstones of the Tipam series. These soils are common in Cachar, Sylhet and some Assam gardens which are put out on spurs of the Naga Hills.

In the Assam Valley two broad series are distinguishable, the Old and New Alluvium. The New Alluvium covers a whole range of deposits, the most recent of which are grey in colour and often poor in plant food below the top nine inches. Some of the

most recent deposits of New Alluvium occur in the Bishnauth district. Older deposits are found in the Jorhat district and still older ones in Doom Dooma and Dibrugarh. Yet older deposits, still classed as New Alluvium, occur in the form of red banks, which have had time to weather and become lateritic. Whilst the grey soils are often low in acidity and at times almost neutral, the red soils are always strongly acid. The red soils are usually friable and well supplied in plant food.

In some places banks of yellow clay stand out of the grey alluvium. These are probably of more recent deposition than the red banks.

Most of the soils of the foothills in the Sibsagar sub-division are of the Old Alluvium series, although some strongly resemble the Red Sandy *Teela* series. Some of the very low banks away from the hills also appear to belong to this last series.

In the Sibsagar sub-district the tea soils of the plains are generally reddish and older than the grey deposits of Jorhat or Lakhimpur. The soils at the Lakhimpur end of Moran appear to be more recent deposits than the average for the district.

Chemically the Sibsagar sub-district tea soils are not very rich. The loss on ignition is about 4%, a low figure for soils of such heaviness. The Grandeau or soluble organic matter varies from 1 to 1.5%. The nitrogen content varies from about 0.10 to 0.12%, the available potash from about 0.005 to 0.010% and the available phosphoric acid from about 0.008 to 0.012%. These values are considerably lower than those of average soils of similar texture and fair repute in England.

The available lime in the Sibsagar tea soils varies from 0.03 to 0.05%, and the soils are generally strongly acid, some showing Hopkins acidity values as high as 1,500. The pH values are usually about 5.4 and well within the range shown by good tea soils. Some of the soils near the Dehing River lack acidity or are alkaline, owing to the newness of the soil.

The question of soil acidity is a most important one so far as tea is concerned. A neutral or faintly acid soil will not

readily support good tea unless it is exceptionally well supplied with organic matter. New deposits usually lack acidity because of high lime content.

The older soils, on the south bank of the Brahmaputra are generally strongly acid. On the north bank of the River, however, owing to limestone outcrops in the Himalayas, it frequently happens that large areas of otherwise fair tea land will not support tea because at some recent geological period they have been flooded by alkaline waters.

The following table gives analysis of typical light and heavy soils from tea gardens in the Sibsagar sub-division.

Table showing analysis of typical Sibsagar Tea soils.

	Suffrai.	Lukwa.	Khongea.	Bhumun.
Mechanical analysis.	%	%	%	%
Coarse sand	7	1	13	23
Fine sand	26	21	36	32
Silt	22	24	16	15
Fine silt	26	28	19	11
Clay	16	20	11	12
Loss on ignition	5·32	4·67	4·48	3·92
Chemical analysis.				
Soluble organic matter (Grandean)	2·57	2·82	1·97	1·35
Total nitrogen	0·13	0·11	0·11	0·10
Available potash	0·023	0·007	0·008	0·012
,, phosphoric acid ...	0·006	0·038	0·004	0·019
,, lime	0·059	0·060	0·045	0·087
Acidity (Hopkins)	537	1366	1071	86
pH value	5·5	5·2	5·4	5·7

The treatment of Sibsagar soils.

Apart from the addition of plant food to the Sibsagar tea soils, their texture makes the addition of bulky organic matter desirable if they are to remain friable under cultivation. Unless an area carries fully grown tea, in which the bushes practically cover the soil, or is well shaded, frequent green cropping is suggested. Apart from this, annual applications of nitrogenous manures and minerals are necessary to keep up outturn.

A 10-maund (800 lbs.) crop of tea removes from the soil about 40 lbs. nitrogen, 8 lbs. phosphoric acid and 20 lbs. potash. The nitrogenous matter in the soil is constantly being converted into nitrates, which are water-soluble and are leached from the soil owing to percolation during the Monsoon period. By means of cropping and leaching the total nitrogen content of a soil under tea may be reduced from about 0.2% to 0.1%, or less, in a period of 20 years. This represents a reduction in the nitrogen content of the top nine inches of an acre of soil from about 6,000 lbs. to 3,000 lbs.

The total potash in the Sibsagar tea soils is about 0.3% and the available about 0.01%. Potash is not easily leached from the soil and is not removed by the crop in as great a quantity as is nitrogen. The available potash does not vary appreciably with time and on this account the addition of potash is of much less importance than nitrogen to most tea soils.

The total phosphoric acid content of the Sibsagar tea soils is about 0.1% and the available 0.005%. Phosphoric acid is not leached from the soil nor is it removed in great quantities by the average tea crop.

According to present ideas based on evidence available, the annual addition of plant food to the average good tea area should be about the following :—

Nitrogen/phosphoric acid/potash = 40/20/20 lbs. per acre.

Manuring may be economically increased to 60 lbs. nitrogen per acre or even more according to the market value of the tea made. If labour is insufficient to pluck the full crop, then less than 40 lbs. nitrogen per acre per annum is sufficient to keep the bush in good condition.

Our recommendations regarding the use of nitrogenous manures are based on Borbhetta experiments carried out over a series of years, but we have not yet such definite information regarding additions of potash and phosphoric acid. The quantities denoted above are given to be on the safe side and, as information accumulates, these suggestions may be modified.

A suitable 5-year manure cycle for the average Sibsagar tea soil is as follows :—

A—Sulphate of ammonia 2 cwt. } per acre in Feb.
Muriate of potash ½ ,, } March or April.

B—Mineral phosphate or basic slag 2 cwt. per acre with a suitable 8-week green crop.
When crop is buried broadcast 1½ cwt. nitrate of soda per acre.

C—Mixture as in A.

D—Sulphate of ammonia 2 cwt.
Muriate of potash ½ ,,
Superphosphate 1 ,,
} per acre in Feb. March or April.
Boga medeloa, Lop and thin during the season.

E—Sulphate of ammonia 2 cwt. } per acre in Feb.
Superphosphate 1½ ,, } March or April.
Bury Boga medeloa at end of season.

The plant food given in lbs. per acre by the artificial manures is as follows. N = nitrogen, P = phosphoric acid (P_2O_5), K = potash (K_2O).

Treatment	Amount	N	P	K
A—Sulphate of ammonia	2 cwts.	45	...	...
Muriate of potash	½ ,,	...	...	28
B—Basic slag	2 ,,	...	40	...
Nitrate of soda	2½ ,,	25	...	...
C—As in A	2½ ,,	45	...	28
D—Sulphate of ammonia	2 ,,	45	...	...
Muriate of potash	½ ,,	...	...	28
Superphosphate	1½ ,,	...	33	...
E—Sulphate of ammonia	2 ,,	45	...	...
Superphosphate	1½ ,,	...	33	...
	17 cwts.	205	106	84

An average good crop of cowpeas should add about 20 lbs. nitrogen per acre to the soil. The first year's loppings of an average good Boga medeloa crop should add 20 lbs. nitrogen per acre and a further 40 lbs. when the crop is buried in the second year.

The cost of this cycle is, at present prices (March, 1931), about Rs. 13/- per acre per annum, not counting freight, application and cost of seed for green crops.

There may be some doubt regarding the continued application of sulphate of ammonia, owing to the development of acidity. The addition of phosphatic manures tends to neutralise this acidity, with the net result that the soil reaction shows no appreciable change over a few years. Very acid soils may be given an application of 2 cwts. Calcium cyanamide in place of sulphate of ammonia once in the cycle, preferably in *A* year.

In giving advice at Tocklai on the subject of manuring, it is essential that we should know the condition, age and yield of the tea. It is also helpful to us if samples of two or three typical top-soils are sent for acidity estimations. The pH estimations are not made by Calcutta analysts but are carried out at Tocklai.

The Mechanical analysis of Sibsagar Soils.

The tables below show typical analysis of soils in each of the three Circles. The class of the soil in the tables is denoted by the chain of numerals used in former soil surveys. The gardens are considered in convenient groups.

Sonari Circle.

The first table includes samples from the three gardens at the Lakhimpur end of the district, *viz.*, Borhat, Borpatra and Bogabagh.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Borhat	1	11	22	40	16	8·48	4, 3, 5, 2, 1.
,, No. 6 ...	*nil*	17	28	28	28	8·03	3, 4, 5, 2, 1.
,, ,, 9 ...	1	9	16	36	32	6·24	4, 5, 3, 2, 1.
,, ,, 4 ...	1	20	24	25	25	5·06	4, 5, 3, 2, 1.
,, ,, 3 ...	1	8	22	32	30	5·73	4, 5, 3, 2, 1.
,, ,, 2 ...	1	9	20	34	30	5·88	4, 5, 3, 2, 1.
Borpatra	2	34	22	21	16	4·46	2, 3, 4, 5, 1.
Bogabagh	5	44	16	20	10	4·50	2, 4, 3, 5, 1.
,, ...	3	38	20	21	10	6·69	2, 4, 3, 5, 1.

The first Borhat sample is a silt loam and the others silty clays. The Borpatra and Bogabagh soils are loams.

The Borhat soil is, perhaps with Namrup, the heaviest tea soil in Assam. It is a yellowish bank, difficult to work unless well green cropped. The subsoil at Borhat contains in places 50% clay. The Borpatra soils are generally rich in organic matter and, on this account, friable. The analysis shown indicates a small loss on ignition (organic matter) and is probably not typical. The Bogabagh soils are of good texture.

The next table shows Sonari, Safrai and Muttrapore samples, all three gardens being close to the hills.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Sonari	5	13	18	23	32	5·76	5, 4, 3, 2, 1.
,, ...	9	26	15	20	25	4·16	2, 5, 4, 3, 1.
,, ...	12	21	20	21	21	4·35	2, 4, 5, 3, 1.
Safrai No. 12 ...	7	14	16	36	23	6·08	4, 5, 3, 2, 1.
,, ,, 12 ...	21	23	15	14	18	4·24	2, 1, 5, 3, 4.
,, ,, 14 ...	7	26	22	26	16	5·32	4, 2, 3, 5, 1.
,, ,, 22 ...	19	31	16	14	16	4·12	2, 1, 3, 5, 4.
Obeypore	6	24	17	28	22	7·45	4, 2, 5, 3, 1.
,, Singlo No. 1 ...	10	28	17	28	14	5·42	2, 4, 3, 5, 1.
Muttrapore No. 3 ...	11	48	20	7	10	5·37	2, 3, 1, 5, 4.

The Sonari soils are clay loams. Those from Safrai are silty clay loams and loams, the latter being represented on Nos. 12 and 22. The Muttrapore sample is a sandy loam.

Some of these soils, *viz.*, Nos. 12 and 22 Safrai and the Muttrapore sample probably belong to the Red Sandy *Teela* series. It is, of course, impossible to designate the series of a soil from its mechanical analysis, although certain characteristics, *e.g.*, a greater clay content than fine silt, denote a well weathered soil, hence an old one.

The next table includes soils from gardens which are situated away from the hills.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Teok No. 12	nil	28	24	23	17	4·70	2,3,4,5,1.
,, 8	1	29	16	25	23	5·57	2,4,5,3,1.
Borahi 8	15	39	10	16	14	4·71	2,4,1,5,3.
,, 18	13	41	10	11	18	5·10	2,5,1,4,3.
,, 19	3	18	13	14	46	6·86	5,2,4,3,1.
Borsali 2	3	20	34	14	23	5·20	3,5,2,4,1.
,, 6	2	16	40	12	23	5·90	3,5,2,4,1.
,, 10	1	30	28	14	21	5·90	2,3,5,4,1.
Deepling 1	20	21	20	19	14	4·13	3,2,1,4,5
,, 12	10	43	15	15	12	3·16	2,4,3,5,1.
Bonamali 3	11	27	30	12	16	4·14	3,2,5,4,1.
,, 5	3	32	29	17	15	4·33	2,3,4,5,1.
,, 11	3	14	29	17	31	6·36	5,3,4,2,1.
,, 17	3	3	23	28	35	7·35	5,4,3,2,1.

The Teok samples are silty clay loams. The first two Borahi samples are sandy loams and No. 19 a silty clay. This last sample is difficult to work unless carefully cultivated and green cropped. The Borahi samples are clay loams and those of Deepling, loams. These last samples are of very good texture, tractable and easy to work. The first two Bonamali soils are similar to those at Deepling, although slightly heavier. Nos. 11 and 17 Bonamali are silty clays.

Nazira Circle.

Analysis in small number only are available for this circle. The first table shows samples from the Lakwa gardens and from Nahorhabi.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Lakwa	nil.	55	18	15	6	4·00	2, 3, 4, 5, 1.
,, No. 10 ...	2	37	22	19	15	3·80	2, 3, 4, 5, 1.
Thirwalbari No. 2 ...	2	12	14	31	34	7·20	5, 4, 3, 2, 1.
Sola No. 7B ...	1	13	43	22	14	5·33	3, 4, 5, 2, 1.
Rajbari No. 2 ...	1	21	24	28	20	4·67	4, 3, 2, 5, 1.
,, No. 13 ...	9	28	14	20	13	5·90	2, 5, 4, 3, 1.
Nahorhabi No. 6 ...	10	25	40	6	15	3·68	3, 2, 5, 1, 4.
,, No. 11A ...	9	37	30	5	15	3·48	2, 3, 5, 1, 4.
,, No. 14 ...	3	38	32	5	18	5 59	2, 3, 5, 4, 1.
,, No. 17 ...	7	38	30	5	14	3·62	2, 3, 5, 1, 4.
,, No. 19 ...	1	23	40	6	23	5·21	3, 5, 2, 4, 1.
,, No. 20A ...	2	47	28	5	14	3·11	2, 8 5, 4, 1.

The first Lakwa sample is a sandy loam and the second a silt loam. The Thirwalbari sample is a silty clay, the Sola sample a silt loam, Rajabari No. 2 a silty clay loam and No. 13 a loam.

The Nahorhabi samples are noteworthy in that they are very short of fine silt and are very definitely well weathered soils. They are loams.

The next table shows three Madoorie samples, 22 further analysis showing samples of similar sonstitution being available. A single Dolebagan sample is shown and one labelled Nazira. The Dolebagan sample was collected because it is definitely an Old Alluvium.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Madoorie	1	23	34	16	19	4·22	3, 2, 5, 4, 1.
,, ...	1	25	33	15	20	4·60	3, 2, 5, 4, 1.
,, ...	1	20	32	16	24	5 29	3, 5, 2, 4, 1.
Dolebagan	23	47	11	9	6	...	2, 1, 3, 4, 5.
Nazira	nil	13	23	33	24	57·4	4, 5, 3, 2, 1.

The Madoorie samples are silty clay loams as is the Nazira sample. The Dolebagan sample is a sandy loam.

The last table of the Nazira Circle includes soil samples from Baghjan and Amgoorie.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Baghjan	15	23	24	13	17	8·45	3, 2, 5, 1, 4.
,, ...	24	34	16	9	11	4·07	2, 1, 3, 5, 4.
,, ...	21	34	19	9	10	4·93	2, 1, 3, 5, 4.
Amgoorie	3	67	12	7	8	3·18	2, 3, 5, 4, 1.
,, Newer soil ...	21	37	23	11	5	3·85	2, 3, 1, 4, 5.
,, Red soil No. 7	9	28	21	14	21	5·79	2, 3, 5, 4, 1.
,, ...	3	28	27	20	17	4·50	2, 3, 4, 5, 1.
,, ...	5	45	18	15	12	3·24	2, 3, 4, 5, 1.
,, ...	2	17	24	29	33	5·17	4, 3, 5, 2, 1.

These soils are much lighter than the average of the district and some resemble the more recent deposits of New

Alluvium found in the Jorhat area. The Baghjan soils are sandy loams. The first Amgoorie sample is a sand, the second a sandy loam, the third a clay loam. The next two samples are loams and the last a silty loam.

Moran Circle.

The first table shows typical soils from Rajabari, Khongea, Attabarie and Rajmai.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Rajabarrie D. 1 ...	30	38	18	4	7	2·66	2, 1, 3, 5, 4.
,, ,, 6 ...	21	48	16	5	7	2·64	2, 1, 3, 5, 4.
,, ,, 9 ...	10	44	25	5	11	4·18	2, 3, 5, 1, 4.
Kampti R ...	25	24	25	8	11	4·20	3, 1, 2, 5, 4.
,, Rl ...	6	25	37	10	17	4·30	3, 2, 5, 4, 1.
,, BT 2 ...	11	29	31	7	16	4·77	3, 2, 5, 1, 4.
,, BT 3 ...	10	23	38	6	17	5·21	3, 2, 5, 1, 4.
Khongea Forest land ...	7	24	11	29	23	5·64	4, 2, 5, 3, 1.
,, ,, ,, ...	13	36	16	19	11	3·84	2, 4, 3, 1, 5.
,, ,, ,, ...	14	18	22	20	18	6·29	4, 3, 2, 5, 1,
,, thatch ,, ...	10	23	18	27	14	6·19	4, 2, 3, 5, 1.
,, tea ,, ...	16	19	20	24	16	4·48	4, 3, 2, 1, 5.
Attabarie No. 11 good ...	7	21	23	24	15	5·03	4, 3, 2, 5, 1.
,, bad ...	5	28	20	24	14	5·17	2, 4, 3, 5, 1.
,, 1921 replanted ...	14	35	13	21	10	5·29	2, 4, 1, 3, 5.
,, Deroi No. 10 ...	16	37	20	14	7	2·98	2, 3, 1, 4, 5.
Chota Deroi No. 16 ...	7	30	24	19	10	4·29	2, 3, 4, 5, 1.
Rajmai Hensua No. 1 ...	13	30	24	12	16	4·76	2, 3, 5, 1, 4.
,, 5 ...	7	38	23	18	10	5·39	2, 5, 3, 4, 1.
,, 6 ...	9	26	32	11	17	4·06	3, 2, 5, 4, 1.
,, 9 ...	11	23	29	13	18	4·68	3, 2, 5, 4, 1.
,, Logahari No. 4.	10	39	21	9	17	4·18	4, 3, 5, 1, 4.
,, Seraknnda 8.	18	27	19	13	18	4·17	2, 3, 5, 1, 4.

The Rajabarrie samples are sands and sandy loams and are, on the whole, the lightest in the Sibsagar district. The Khongea, Attabarrie and Rajmai samples are all loams.

The Khongea soils approach the average for the Moran district. It is of interest to note that the first and second samples of forest soil show nitrogen contents of 0.163%, 0.150% and 0.166% against a value of 0.111% on the tea land. The thatch land shows a nitrogen content of 0.132%.

The Attabarrie soils from No. 11 good and bad patches, were examined for acidity. That of the good patch was found to be 231, whilst on the bad patch the value was only 14. Lack of acidity is one cause of the poorness of the tea in this particular case and sulphur dressings, additions of organic matter or continued applications of sulphate of ammonia would do well here.

The next table shows samples from Gosaibari and Derai all of which are loams of good texture.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Gosaibari No. 3 ...	10	36	21	17	12	3·00	2, 3, 4, 5, 1.
,, 7 ...	4	35	26	17	14	4·24	2, 3, 4, 5, 1.
,, 9 ...	11	31	18	14	21	5·13	2, 5, 3, 4, 1.
Derai ...	6	36	21	18	14	4·14	2, 3, 4, 5, 1.
,, ...	4	32	10	33	17	4·18	4, 2, 5, 3, 1.

The final table shows samples from Bhamun, Ouphulia and Teloijan. The Bhamun samples are sandy loams, these of Ouphulia loams. Of the Teloijan samples, the first is a loam and the others sandy loams.

Garden.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ignition.	Class.
Bhamun No. 1 ...	38	23	14	10	11	4·34	1, 2, 3, 5, 4.
,, 2 ...	23	32	15	11	12	3·92	2, 1, 3, 5, 4.
,, 3 ...	26	32	15	12	13	4·26	2, 1, 3, 5, 4.
Ouphulia No. 1 ...	13	24	16	27	13	5 0	4, 2, 3, 1, 5.
,, 2 ...	20	28	15	20	11	4·59	2, 4, 1, 3, 5.
,, 3 ...	8	28	21	24	14	3·00	2, 4, 3, 5, 1.
,, 4 ...	7	38	17	20	13	2·30	2, 4, 3, 5, 1.
,, 5 ...	28	19	16	21	11	2·01	1, 4, 2, 3, 5.
Teloijan No. 1 ...	5	37	30	7	16	5·16	2, 3, 5, 4, 1.
,, 2 ...	12	40	22	4	17	5·03	2, 3, 5, 1, 4.
,, 5 ...	28	24	21	3	15	5·48	1, 2, 3, 5, 4.
,, 8 ...	36	26	18	2	11	4·56	1, 2, 3, 5, 4.

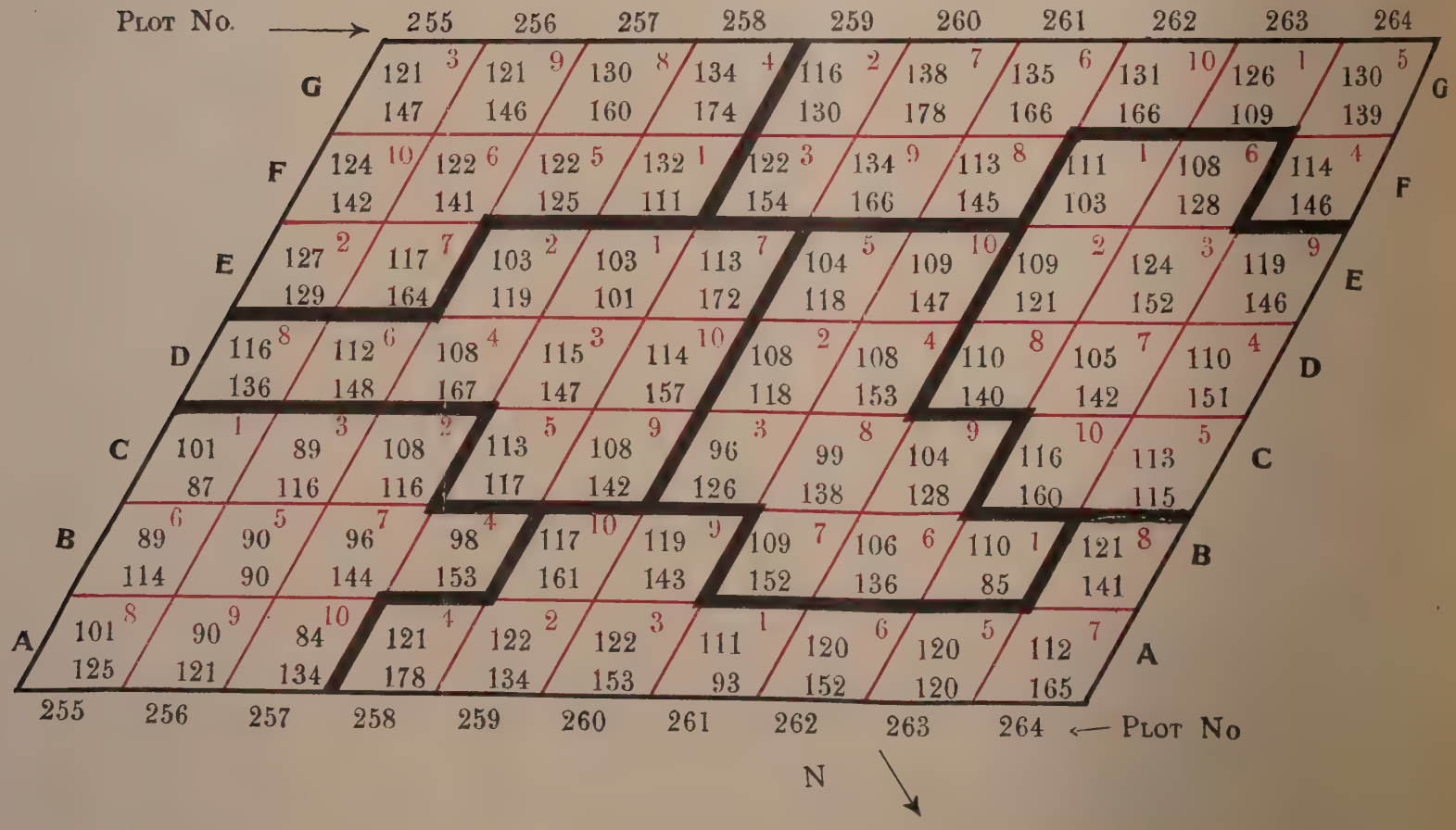
Much of the soil in this area is recent New Alluvium and many under-acid and alkaline patches occur. Tea should be put out here only after acidity estimations have shown that this factor is suitable for tea.

PLAN OF EXPERIMENTAL PLOTS.

The heavy black lines divide the area into 7 blocks selected so that the ten sub-plots in each block are as nearly as possible alike in yield in 1928 & 1929. The red number in right hand corner of eaeh sub-plot indicates the treatment given in 1930.

1. nil (check plots.
2. 40 lbs. nitrogen in March
3. 80 lbs. nitrogen in March
4. 120 lbs. nitrogen in March
5. 20 lbs. nitrogen in March, 20 „ „ „ June
6. 40 lbs. nitrogen in March, 40 „ „ „ June
7. 60 lbs. nitrogen in March, 60 „ „ „ June
8. 40 lbs. nitrogen in March, 40 „ „ „ May
9. 40 lbs. nitrogen in March, 40 „ „ „ July
10. 40 lbs. nitrogen in March, 40 „ „ „ May, 40 „ „ „ July

The black figures in each sub-plot show yield to nearest lb.
Upper figure in 1929 when unmanured.
Lower figure in 1930 after manuring.



Two plants produced from hard bamji shoots with red bark.—Both have

This plant was grown from a normal size

A NOTE ON THE PROPAGATION OF TEA BY GREEN SHOOT CUTTINGS.

By

A. C. Tunstall.

During a visit to Tocklai, Mr. H. Clark, a Cachar planter, mentioned that he had propagated tea successfully from green shoots. He had obtained well grown bushes when the experiment was interrupted by his moving to another garden. During the past year experiments have been carried out at Tocklai to test this method of propagation. In the first experiment five succulent shoots and five banji ones were planted in wet soil under a bell jar and placed near a window with a north light. Two of these shoots produced roots and one of them is still growing seven months after planting. The experiment was a failure owing to the lack of æration in the soil and the confined space under the bell jar.

In September last a further experiment was made under better conditions. Five trays were filled with bheel soil obtained specially from Pathini Tea Estate in Sylhet. The soil was watered until it was damp but not wet. The trays were placed in separate compartments in a glass case fully exposed to a north light. The air inside the compartments was kept saturated so that no undue loss of moisture could take place. In each tray twenty shoots were planted with about an inch of the stems buried in the soil. The shoots were of five different types.

Six months after planting the surviving shoots were dug up and transplanted. The photographs accompanying this note were taken at that time. The following table gives the results of the experiment at the end of six months.

Green cuttings six months after planting.

Kind of shoot (20 in each case)		Rooted.		Not rooted.	
		Good roots.	Number with root growth with abnormal callus.	Alive.	Dead.
From sides.	Hard banji shoots with red bark ...	7	3	1	9
	,, ,, ,, without red bark	12	4	0	4
	Soft ,, ,, ,, ,, ,,	12	4	1	3
From centres.	,, ,, ,, ,, ,, ,,	14	3	0	3
	Ordinary plucking shoots ...	8	1	0	11
		53%	15%	2%	30%
	Total percentage ...	68%		32%	

From the above experiment it is clear that a fair percentage of green shoots will produce satisfactory roots if planted under favourable conditions. Before this knowledge is of practical importance to the industry it is necessary to find out what yield is obtainable from the bushes grown from green shoots and whether the kind of shoot used for propagation influences the yield. Another point of importance is whether the seed crop from bushes which have originated from green shoot cuttings will be satisfactory. If this method of propagation is found to be satisfactory it opens up many possibilities.

In every plot of tea exceptional bushes are to be found. For instance in mosquito blighted areas certain bushes may be observed to be flushing well when all the others are "shut up". To propagate such bushes by seed it would be necessary to allow them to grow unplucked for some years before a satisfactory crop of seed is obtainable. Further the plants arising from such seed would not all resemble their parents and further selection would be necessary. It would probably be twenty years at least before much progress could be made. By means of green shoot cuttings sufficient plants to make at least an acre of seed garden could be obtained in one year from a single bush and large num-

bers of plants could be obtained by cuttings from the seed trees without seriously interfering with the seed crop. In this way selection could be carried out on a large scale with much less loss of time than would be the case were seed alone employed.

Further experiments on a larger scale are being made and for this purpose a number of cold frames resembling cucumber frames are being constructed.

Anyone wishing to repeat these experiments should keep in mind the following points.

A green shoot has very little reserve carbohydrates but it has the means of producing them if exposed to light. In order to prevent the leaves from drying up before roots are formed it is necessary to keep them in a saturated atmosphere. The cut ends of the shoots will not callus satisfactorily if excluded from air. It is therefore necessary to use a well ærated soil and to avoid waterlogging. Fibrous bheel soil appears to be very suitable for this work. There is no need to have an elaborate humidifying apparatus. If the frame be kept closed, syringing with a fine spray once a day will keep the air and soil sufficiently moist.